

- 12 -

What is claimed is:

1. An adhesive composition, comprising:
5 soy protein or a mixture of soy protein and lignin;
 at least one substantially formaldehyde-free curing agent that includes at least one
 amine, amide, imine, imide, or nitrogen-containing heterocyclic functional group that can
 react with at least one functional group of the soy protein; and
 at least one compound selected from a boron compound, a group IA oxide or
10 hydroxide, or a group IIA oxide or hydroxide.
2. The composition according to claim 1 wherein the composition is substantially
formaldehyde-free.
- 15 3. The composition according to claim 1 wherein the composition includes about
0.5 wt. % to about 10 wt. % of the at least one boron compound, group IA oxide or
hydroxide, or group IIA oxide or hydroxide, based on the dry weight of the composition.
- 20 4. The composition of claim 1 wherein the boron compound is selected from boric
acid, a boron salt, or a borate ester.
- 25 5. The composition of claim 1 wherein the boron compound comprises sodium
borate, sodium borohydride or sodium tetraborate.
- 30 6. The composition of claim 1 wherein the curing agent is a reaction product of an
epoxide with a polyamine resin, a reaction product of an epoxide with a polyamidoamine
resin, or reaction product of epoxide with a polyamide resin.
- 35 7. The composition of claim 1 wherein the curing agent comprises a polyalkylene
polyamine-epihalohydrin resin.
8. The composition of claim 7, wherein the curing agent comprises a reaction
product of epichlorohydrin with ethylenediamine, bis-hexamethylenetriamine or
hexamethylenediamine.

- 13 -

9. The composition of claim 5 wherein the soy protein comprises soy flour and the curing agent comprises a reaction product of epichlorohydrin with ethylenediamine, bis-hexamethylenetriamine or hexamethylenediamine.

5 10. The composition according to claim 3 wherein the composition includes about 2 wt. % to about 30 wt. % of the at least one curing agent, based on the dry weight of the composition.

10 11. The composition according to claim 1, wherein the composition comprises a reaction product of the soy protein, the at least one curing agent, and the at least one compound.

15 12. The composition of claim 1, wherein the at least one compound is selected from sodium hydroxide, potassium hydroxide, calcium hydroxide, or calcium oxide.

 13. The composition of claim 8, wherein the at least one compound is selected from sodium hydroxide, potassium hydroxide, calcium hydroxide, or calcium oxide.

20 14. A method for making an adhesive composition comprising mixing together: soy protein or a mixture of soy protein and lignin; at least one substantially formaldehyde-free curing agent that includes at least one amine, amide, imine, imide, or nitrogen-containing heterocyclic functional group; and at least one compound selected from a boron compound, a group IA oxide or hydroxide, or a group IIA oxide or hydroxide.

25 15. A method for making an adhesive composition comprising: mixing together at least one compound selected from a boron compound, a group IA oxide or hydroxide, or a group IIA oxide or hydroxide with at least one substantially formaldehyde-free curing agent that includes at least one amine, amide, imine, imide, or
30 nitrogen-containing heterocyclic functional group; and contacting the resulting product with soy protein or a mixture of soy protein and lignin.

35 16. The method of claim 15, wherein the at least one compound/curing agent product is contacted with the soy protein or mixture of soy protein and lignin under

- 14 -

conditions sufficient for reacting the boron compound/curing agent product with the soy protein.

17. The method of claim 15, wherein the soy protein comprises soy flour, the at
5 least one curing agent comprises a reaction product of epichlorohydrin with
ethylenediamine, bis-hexamethylenetriamine or hexamethylenediamine, and the at least one
compound is selected from boric acid, a boron salt, a borate ester, sodium hydroxide,
potassium hydroxide, calcium hydroxide, or calcium oxide.

10 18. An adhesive composition made according to claim 17.

19. An adhesive composition produced from the following ingredients:
soy protein or a mixture of soy protein and lignin;
at least one substantially formaldehyde-free curing agent that includes at least one
15 amine, amide, imine, imide, or nitrogen-containing heterocyclic functional group; and
at least one compound selected from a boron compound, a group IA oxide or
hydroxide, or a group IIA oxide or hydroxide.

20. An adhesive composition, comprising:
20 a first component selected from at least one of soy protein, lignin, or a mixture
thereof; and
at least one substantially formaldehyde-free curing agent selected from a reaction
product of epichlorohydrin with ethylenediamine, a reaction product of epichlorohydrin
with bis-hexamethylenetriamine, or a reaction product of epichlorohydrin with
25 hexamethylenediamine.

21. The composition according to claim 20 wherein the composition is substantially
formaldehyde-free.

30 22. The composition according to claim 20 wherein the composition includes about
2 wt. % to about 30 wt. % the curing agent, based on the dry weight of the composition.

23. The composition according to claim 20, wherein the first component is soy
protein.

35

- 15 -

24. The composition according to claim 23, wherein the soy protein comprises soy flour.

25. The composition according to claim 20, wherein the composition comprises a reaction product of the first component and the at least one curing agent.

26. The composition according to claim 20, wherein the first component is lignin.

27. A method for making an adhesive composition comprising mixing together:
a first ingredient selected from soy protein, lignin, or a mixture thereof; and
at least one substantially formaldehyde-free curing agent selected from a reaction product of epichlorohydrin with ethylenediamine, a reaction product of epichlorohydrin with bis-hexamethylenetriamine, or a reaction product of epichlorohydrin with hexamethylenediamine.

28. An adhesive composition made according to claim 27.

29. A method for making a lignocellulosic composite, comprising:
applying an adhesive composition to at least one lignocellulosic substrate, the adhesive composition comprising (i) soy protein, (ii) at least one substantially formaldehyde-free curing agent that includes at least one amine, amide, imine, imide, or nitrogen-containing heterocyclic functional group that can react with at least one functional group of the soy protein, and (iii) at least one compound selected from a boron compound, a group IA oxide or hydroxide, or a group IIA oxide or hydroxide; and
bonding the adhesive-applied lignocellulosic substrate to at least one other lignocellulosic substrate.

30. The method of claim 29, wherein the bonding comprises applying heat and pressure to an assembly of the adhesive-applied lignocellulosic substrate and the other lignocellulosic substrate.

31. The method of claim 29, wherein the lignocellulosic substrates comprises comminuted wood particles and the method comprises:

- 16 -

blending about 1 to about 12 weight percent of the adhesive composition with a mixture of the comminuted wood particles, the weight percent being based on the combined weight of the adhesive composition and the comminuted wood particles;

forming the adhesive/wood particle blend into a predetermined configuration; and
5 applying heat and pressure to the formed blend.

32. The method of claim 29, wherein the lignocellulosic substrates comprises a wood veneer substrate and the method comprises:

applying the adhesive composition to at least one surface of the wood veneer
10 substrate;
forming an assembly of the adhesive-applied wood veneer substrates; and
applying heat and pressure to the assembly.

33. The method of claim 29, wherein the at least one compound is selected from
15 boric acid, a boron salt, a borate ester, sodium hydroxide, potassium hydroxide, calcium hydroxide, or calcium oxide, and the curing agent comprises a reaction product of epichlorohydrin with ethylenediamine, bis-hexamethylenetriamine or hexamethylenediamine.

20 34. A method for making a lignocellulosic composite, comprising:
applying an adhesive composition to at least one lignocellulosic substrate, the adhesive composition comprising (i) a first component selected from soy protein, lignin, or a mixture thereof and (ii) at least one substantially formaldehyde-free curing agent selected from a reaction product of epichlorohydrin with ethylenediamine, a reaction product of
25 epichlorohydrin with bis-hexamethylenetriamine, or a reaction product of epichlorohydrin with hexamethylenediamine; and
bonding the adhesive-applied lignocellulosic substrate to at least one other lignocellulosic substrate.

30 35. The method of claim 34, wherein the bonding comprises applying heat and pressure to an assembly of the adhesive-applied lignocellulosic substrate and the other lignocellulosic substrate.

36. The method of claim 34, wherein the lignocellulosic substrates comprises
35 comminuted wood particles and the method comprises:

- 17 -

blending about 1 to about 12 weight percent of the adhesive composition with a mixture of the comminuted wood particles, the weight percent being based on the combined weight of the adhesive composition and the comminuted wood particles;

5 forming the adhesive/wood particle blend into a predetermined configuration; and
 applying heat and pressure to the formed blend.

37. The method of claim 34, wherein the lignocellulosic substrates comprises a wood veneer substrate and the method comprises:

10 applying the adhesive composition to at least one surface of the wood veneer
 substrate;
 forming an assembly of the adhesive-applied wood veneer substrates; and
 applying heat and pressure to the assembly.

15 38. The method of claim 34, wherein the first component is soy protein.

39. The method of claim 34, wherein the first component is lignin.

40. A lignocellulosic composite made according to the method of claim 29.

20 41. A lignocellulosic composite made according to the method of claim 34.